

November 5, 2008

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Program Manager I
Site Investigation and Restoration Branch
State of Delaware
Department of Natural Resources and Environmental Control
Division of Air and Waste Management
391 Lukens Drive
New Castle, DE 19720-2744

**Subject: Final Review, DuPont RI/RA Report
(Schnabel Reference 06150049 Task 9)**

NOV 10 2008

Dear Mr. Salahuddin:

As requested, Schnabel Engineering, LLC (Schnabel) conducted a review of the documents, which the Delaware Department of Natural Resources and Environmental Control (DNREC) provided us regarding DuPont's Hay Road Edgemore facility. DNREC provided these documents during June of 2007, and during the weeks of October 6 and 13, 2008, which detailed DuPont's environmental, hydrogeological, and geotechnical work performed on this site during 2007 and 2008.

The documents that we reviewed included the following:

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|--|------------------|
| • DuPont Comments to Schnabel Engineering Report | March 2, 2007 |
| • DNREC Comparison Table | June 27, 2007 |
| • DuPont's RI/RA Addendum Report | September 2008 |
| Appendices A, B, E, I, J, K, L, and M | |
| Figures B-9 and B-15 | |
| Revised RI Tables | |
| Revised RI Figures | |
| • DNREC Draft Report Evaluation | October 2008 |
| • DNREC Draft Report Evaluation | October 10, 2008 |
| • DNREC Health and Risk Assessment Comments | October 2008 |
| • DNREC Additional Comments on RI/RA Addendum | October 2008 |

This report represents the findings of our review, and that of our subconsultant (LRM Consulting, Inc. [LRM]), of the referenced documents; and includes information contained in our preliminary draft report submitted on October 23, 2008.

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COMMENTS ON THE RI/RA ADDENDUM REPORT

The following summarizes comments based on our review of DuPont's RI/RA Addendum Report. These comments focus on the main report. We present the comments in the order in which the underlying subjects appear in the report.

Comment 1 – General Comments on DuPont's RI/RA Addendum Report: The level of technical writing in the submissions provided by DuPont is not satisfactory, and their reports continue to obfuscate a clear presentation of facts. We recommend that there be a clear division between the objective reporting of results and the protocols used. The division should be distinctly and organizationally separate from discussion and interpretation. All speculative narratives and opinions should be removed from the submissions. Data, modeling assumptions, and simulation results should adhere to the same presentation format.

Section 2 should be reorganized and focused on an objective reporting of the field data collection (borings, well installations, water level measurements, etc.) and dredged material (DM) and iron rich material (IRM) testing programs. Emphasis should be placed on materials, methods, and the actual measurements. Borings (presented as revised Section 2.1) should be co-plotted on a fence diagram. The geologic context/interpretations should follow in a later section. All hydrogeologic information, discussion, and narrative should be postponed and included in a revised Section 4.0.

The revised Section 2.2 should focus on a means and methods reporting of DM materials testing. ASTM or other appropriate established protocols should be explicitly cited in the text and tables (especially Tables 2 and 3). Tables should also include sample IDs so they can be effectively matched with the borings logs, which should also be presented in this section. Currently the sample ID and associated grain size data in Appendix F does not match Table 2 and should be corrected. It is important to note that there is no grain size data presented for IRM in Appendix F. Any relevant calculation procedures, if any, should be justified and documented. The IRM materials testing (Section 2.3) should be likewise organized. Field tests such as slug tests, etc., should be presented beginning with Section 2.4. The complete materials testing results from the soils lab for the DM and IRM should be presented as a stand-alone Appendix.

In summary, we are recommending the above organizational changes to the report so that a person reviewing this report and its associated attachments can better understand and follow the process leading to the conclusions.

Comment 2 (by LRM) – Section 1.3: DuPont Property Location and Description: Page 3 of the RI Addendum states that the original coatings applied to the IRM have been changed to a fiber-reinforced cement (Posi-Shell®) coating, with the latest application occurring in Spring 2008. Additional information, including photographs, should be included in the RI/RA Addendum Report to demonstrate the effectiveness of the new coating as the original coatings did not prohibit vegetative growth and potential human and ecological exposure to soils and vegetation on the IRM (see Schnabel Engineering, 2006).

Comment 3 – Section 2.2.2: Sludge Drying Site Hydrogeology: An accurate determination of the hydraulic conductivity (K) of the IRM, DM, and the underlying water bearing zones is required to

correctly model the hydrogeology of these units and to assess the risk of the proposed remedy. As required by DNREC, DuPont collected additional samples (Shelby tubes) of these three units for in-lab K determination during the recent field investigation portion of the Site Investigation (SI).

The dredged material (DM) narrative contained in Section 2.2.2 (top of Page 12) of the RI/RA containing the words “typically,” “characteristically,” “typically exceed,” “characteristic of clays and silts,” leads one to believe that the vertical K factors were assumed or estimated. The source of this information should be clarified. To determine the horizontal K, DuPont performed slug tests on the DM in older wells (MW-33R and MW-35), which were off the footprint and in newer monitoring wells (MW-72 [off the footprint], MW 71 and MW-73 [edge of footprint] and Pile-1 [in the footprint]). The narrative in Section 2.2.2 should be modified to reflect that slug tests were performed on these wells. The location and spacing of the additional slug tests appear to have encompassed the conditions of the DM beneath the proposed footprint.

As part of our review, we requested the actual geotechnical laboratory reports regarding the ASTM testing (not received as of the date of this report). We recommend that a copy of these reports be included in the RI/RA as an Appendix to the report.

There is a reference on Page 12 of the RI/RA concerning the Pigeon Point and Cherry Island landfills being located by the Delaware Solid Waste Authority (DSWA) on this type of sediment due to its impermeability. We recommend that this reference be removed from the document since it has nothing to do with the project site.

Comment 4 – Section 2.3: Iron Rich Material: As was the case with the DM discussion, the narrative describing the K of the IRM in Section 2.3, Page 13, uses the same set of phrases and words to establish a typical K factor for the IRM. As part of our review, we requested the actual geotechnical laboratory reports regarding the ASTM testing (not received as of the date of this report). We recommend that a copy of these reports be included in the RI/RA as an Appendix to the report.

It is important to note that Shelby tube samples of the IRM were collected in the new borings and monitoring wells from the top several feet (three samples) and from the bottom several feet (two samples) of the IRM pile. IRM at these horizons may be weathered.

Additionally, the words “trace amounts of sand and gravel” referring to 7 ft of silty sand in a 13-ft horizon should be rephrased.

Comment 5 (by LRM) – Section 3.1: Identification of COCs and Screening Criteria: On Page 17 of the RI Addendum, the statement is made that all chemicals detected to date are included as chemicals of potential concern (COCs) and evaluated as part of the COC screening evaluation; these results were presented on Table 4 of the RI Addendum. However, a simple comparison of Table 4 with Table 1a of Appendix M (which reportedly summarizes the constituents detected in the IRM and the dredge material [DM]) indicates that numerous detected chemicals have been omitted from the COC screening process in Section 3.1 of the RI Addendum. These include many volatile organic compounds (VOCs), semi VOCs (SVOCs), and heavy metals. The COC screening in Section 3.1 and on Table 4 should include all chemicals detected to date and should be accordingly revised.

Also, the first two sentences in the final paragraph of Section 3.1 on Page 16 should be removed since they are incorrect.

Comment 6 – Section 3.3 Dredge Material: Section 3.3 on Page 20 of the report states that the sample depth of the DM is from the top of the DM. This is incorrect and should be changed. It is important to note that only BORING Pile-1 and BORING Pile-5 satisfied the DNREC requirement that DM samples be collected at 2.5 ft intervals.

Comment 7 – Section 3.4.3 Additional Observations: The fact that chloride is an important player in the overall geochemistry and hydrogeology of the site warrants a much more detailed evaluation and understanding of this contaminant. The fact that there are no Uniform Risk-Based Standards (URS) for chloride in ground water does not eliminate the importance of its movement and potential interaction with other compounds. The statement about a “transient effect” should be re-examined since the referenced activities are recent compared to the thousands of years that the risk model is projecting for movement of metals, organics, and other compounds across the site.

Schnabel’s experience with Delaware River/Schuylkill River DM regarding chloride is limited to Synthetic Precipitation Leaching Procedure (SPLP) data. This data indicates a range of 1 to 5 mg/L of chloride in the leachate from DM samples. Since chloride is extremely leachable, we believe the representative source may have a very low concentration. Because of this, we do not believe that the DM can be a source for such high concentrations of chloride in the site’s ground water, and therefore the reference to DM as a possible source for chloride should be removed from this section on Page 24 or revised.

Comment 8 (by LRM) – Section 5.1: DNREC Remediation Standard Evaluation: On Page 33 and in Table 5, risk estimates are generated for direct and indirect exposure to COCs in soil and ground water for the onsite industrial exposure scenario; however, only select COCs are included in these calculations. Many detected chemicals have been apparently excluded from these risk calculations because their detected concentrations are below URSs. This methodology is flawed given that the numerous other COCs, including many highly toxic VOCs, SVOCs, and heavy metals detected to date (see Table 1a of Appendix M) contribute to the cumulative health risks calculated in Table 5 and referred to on Page 33. Importantly, the cumulative effect of detected chemicals is not limited to chemicals whose individual risk exceeds the target risk level (e.g., 1×10^{-6}) and or hazard quotient (0.1); rather, risk/hazards below these levels can contribute to the overall risk/hazard, resulting in potentially significant cumulative risks/hazards.

Also worth noting is that the incomplete cumulative risks/hazards shown on Table 5 already exceed and/or infringe on acceptable/target risk/hazard levels; hence, the addition of the incremental risk/hazards for the many other detected chemicals shown in Table 1a will necessarily result in further exceedance of acceptable risk levels. For completeness and technical merit, the risk calculations should be accordingly revised.

Comment 9 – Miscellaneous Comments on DuPont’s RI/RA Addendum Report:

- Results from the Shelby tube sample recovered from approximately 21 ft below ground surface (BGS) in BORING Pile-1 could not be located within the documents. Also,

compositional (Appendix I) or geotechnical data (Appendix F; Table 3) cannot be located for Sample 2 from BORING Pile-3, the bulk geotech sample for the IRM. The description of the zone from 4 to 20 BGS should be labeled as "IRM visually classified as..." to be consistent with all other borings logs. All other IRM samples were collected at the fringes of the IRM (top/bottom interfaces) where mixing and weathering may have significantly changed the IRM composition. The DM sample from MW-72 does not appear to have been evaluated for geotech or totals purposes (cannot find data).

- K values in the RI/RA Addendum Report require dual consideration of diffusive and advective transport. The report completely neglects the former, and it is the dominant mode in low K materials.
- SPLP data clearly indicate that soluble cations (Na, Ca, Mg, etc.) are higher in IRM than in the other media. Vertical gradient exists; it is just a matter of water flow. Arsenic, however, may be associated with the DM, as our data from Fort Mifflin DM indicates.
- SPLP pH data should be shown in Appendix I. Soluble salts data that goes with the metals was apparently not included but should be.
- Section 2.8 is inappropriate, presumptive, and should be removed in its entirety. The section has nothing to do with the newly collected data.
- The objective for presenting fines distribution on Figure 8 should be clarified.

COMMENTS ON DUPONT'S REVISED RISK-BASED SCREENING AND RISK ASSESSMENT REPORT – APPENDIX M

Our subconsultant, LRM, reviewed the documents referenced above, and in particular Appendix M of the Addendum Report. The following summarizes comments prepared based on this review. These comments are focused on the revised risk-based screening and risk assessment, Appendix M. The comments are presented in the order in which the underlying subjects appear in the referenced appendix.

Comment 10 – Appendix M, Section I: Introduction: Per its title, this appendix is meant to address updates to the previous risk assessment based on newly collected soil and ground water data; however, the updates presented are to the soil-leaching-to-ground water and the subsequent ground water-discharge-to-surface water exposure pathway. For consistency and technical merit, all exposure pathways included in the previous assessment should be updated and evaluated quantitatively, incorporating the points made in Comment 8 above.

Comment 11 – Appendix M, Section I: Introduction: The approach used in Appendix M to evaluate potential risks to human and ecological receptors at the surface water bodies is based on the risk-based criteria (RBC) approach (American Society for Testing and Materials [ASTM] 1997)¹.

¹ ASTM. (1997). Standard Guide for Risk-Based Corrective Action Applied at Chemical Release Sites, version 9.0, August.

Specifically, this approach back-calculates risk-based concentrations (referred to in the Appendix as closure screening levels [CSLs]) for COCs in IRM soils and leachate from ambient water quality criteria (AWQC) for ecological impacts and risk-based surface water concentrations based on protection of human health during swimming. The back-calculation is based on the calculated attenuation along the path of migration from the IRM to assumed points of exposure within the surface water bodies. Subsequently, the COC-specific CSLs are compared to detected concentrations of COCs in IRM soils and IRM leachate to determine whether significant ecological and/or human health impacts may occur at points of exposure in the surface water bodies.

A significant shortcoming of the above approach as implemented is that it does not account for the cumulative effects of COCs to aquatic or human receptors at the surface water bodies. Note that the CSLs have been developed independent of the presence and/or impact of any other chemical to the receptor. They are developed and used in the screening process as if no other chemical or exposure pathway results in exposure to and/or health impacts on ecological or human receptors. In actuality, these effects are cumulative and must be accounted for based on the contribution from all COCs and all exposure pathways yielding chemical mass to the surface water bodies. Hence, estimation of baseline risks/hazards is necessary to properly evaluate the significance of the COCs detected at the site.

As an example, if the detected concentration of a chemical is equal to 90% of its CSL back calculated from the AWQC, then the ecological hazard associated with that chemical is 0.9. While seemingly protective of the target hazard of 1.0 when considered by itself, the conclusion may be made that there are no significant ecological hazards associated with that chemical at the site; however, there are indeed numerous other chemicals, which are also compared to their respective CSLs, each contributing a proportional incremental hazard to that receptor. The net ecological hazard must account for the sum of all such proportions, reflecting the cumulative effect of all COCs impacting the surface water bodies. Based on the numbers already presented in Tables 11a through 12b of Appendix M, cumulative COC hazards and risks exceed target levels for select exposure scenarios, warranting further evaluation and/or corrective action.

Comment 12 – Appendix M, Section II.A: Exposure and Risk Evaluation: While Appendix M acknowledges the potential for leaching of COCs from the IRM to underlying ground water and the subsequent migration to the surface water bodies, it does not appear to quantitatively evaluate the potential for leaching of COCs detected in DM soils and/or first water-bearing zone (WBZ) soils. This section of the report should clearly describe and distinguish between the sources of COCs in soil (i.e., IRM, DM, and WBZ) used to evaluate the soil leaching-to-ground water and subsequent ground water-discharge-to-surface water migration pathway. Inclusion of impacts associated with COCs in DM and WBZ soils will only increase the already significant cumulative risks discussed in Comment 5.

Comment 13 – Appendix M, Section II.A: Exposure and Risk Evaluation: Expanding on Comment 3, Appendix M appears to ignore the more direct ground water-discharge-to-surface water pathway for COCs, which have already leached to ground water underlying the IRM. This pathway represents the most prevalent and imminent exposure pathway in terms of potential impacts to the two surface water bodies. Specifically, the impact to surface water associated with the maximum concentration of all COCs detected in ground water at their respective locations should be

quantitatively evaluated. Once again, this evaluation should recognize that the ecological and human health impacts posed by discharge of currently impacted ground water to the surface water bodies are additive with the impacts posed by future leaching of COCs from soils within the three zones (IRM, DM, and WBZ) discussed in Comments 5 and 8.

Also worth noting are the fate and potential exposure pathways to the runoff component of the rainfall landing on the IRM, which do not appear to have been addressed. As shown on Figure 1 of Appendix M, this runoff eventually reaches the ground surface, at which point it may: (1) pool and be subject to human exposure; (2) pool and infiltrate into the DM, eventually reaching the WBZ and the surface water bodies; and/or (3) runoff directly to the surface water bodies. The direct exposure by daily site occupants and the COC mass contribution to the surface water bodies from these exposure pathways warrant a quantitative evaluation and should be added in terms of cumulative impacts to surface water receptors.

Comment 14 – Appendix M, Section II.B: Exposure and Risk Evaluation: Selection of COCs for the soil-leaching-to-ground water and subsequent ground water-discharge-to-surface water pathway was based primarily on adoption of the five metals and the focused set of persistent, bioaccumulative, and toxic (PBT) compounds defined by the US Environmental Protection Agency (USEPA, 2001). However, this document was not included on the reference list and no other bases were provided.

In addition to the above-referenced COCs reportedly defined by the USEPA, Page 5 of Appendix M states that other detected chemicals were included as COCs based on a screening of their maximum detected soil concentrations versus USEPA Region III Soil Screening Levels (SSLs); detected chemicals in soil with no assigned SSLs were reportedly automatically included as COCs. However, as shown on Table 1a of this appendix, there are several chemicals, which were indeed detected within IRM and DM soils, but were not included as COCs despite not having published SSLs. These include multiple SVOCs such as acenaphthylene, benzo(a)pyrene, benzo(g,h,i)perylene, 1,4-dichlorobenzene, 4-methylphenol, and phenanthrene, many with known elevated aquatic toxicities. In addition, naphthalene was incorrectly excluded as a COC on Table 1a, despite significant exceedance of its reported SSL. According to the rationale used in this appendix, all of these compounds should be included as COCs, with their respective ecological hazard and human health risk contribution added to those of the other soil and ground water COCs.

Related to the SSL screening, it should also be noted that the report makes use of the SSL corresponding to a dilution-attenuation-factor (DAF) of 20, herein referred to as SSL20; however, no proper reference was provided for the SSLs (the link has apparently expired), no technical bases were set forth in the report for the assumptions used by the USEPA in developing the SSL20, and there are no defensible bases for the report's selection of SSL20. Importantly, USEPA (1996)² states that since the migration-to-ground water SSLs are most sensitive to the DAF, site-specific dilution factors should be calculated in lieu of the DAF 20 values. This sensitivity is observed in Table 1a, where if the SSLs are reduced by one-order-of-magnitude, several more chemicals detected in IRM and DM would have to be added to the list of COCs; these include benzo(a)anthracene, 4-chloroaniline, antimony, barium, selenium, and silver.

² USEPA (1996). Soil Screening Guidance User's Guide, 2nd Edition. Retrieved from: <http://www.epa.gov/superfund/health/conmedia/soil/pdfs/ssg496.pdf>

Lastly, exclusion of any chemical known to be present in IRM, DM, and WBZ soils would inherently and inappropriately eliminate the ability to estimate total cumulative human health risks and ecological hazards at the surface water bodies. To maintain technical defensibility, all chemicals detected in IRM, DM, and WBZ soils should be included as soil COCs and quantitatively evaluated for their cumulative impacts to the surface water bodies; this eliminates the need for the indefensible SSL screening.

Comment 15 – Appendix M, Section II.B: Exposure and Risk Evaluation: Page 6 of Appendix M states that toxic equivalents were calculated using the 1998 World Health Organization (WHO) toxic equivalency factors (TEFs), using one-half the detection limit as a surrogate for non-detected analytical results. As previously commented (Schnabel Engineering, 2006), the WHO has since updated its TEFs (WHO, 2005)³, and their use over the older TEF values is recommended.

Comment 16 – Appendix M, Section II.D: Modeling of Leaching and Groundwater Transport: The application of the HELP model for estimating of recharge to ground water is not well documented in Appendix M. Correspondingly, copies of the highly useful model input and output data files are not provided, prohibiting confirmation of the calculations and a clear understanding of the approach.

While the RI Addendum text is generally vague and highly unclear as to the occurrence of ground water, including depth to ground water, within the various hydrogeologic units, Figure 1 of Appendix M suggests shallow ground water occurs within the DM. This would suggest that the bottom boundary of the one-dimensional domain used by the HELP model would correspond to the water table at some point within the DM; insufficient information is included in the report to decipher this. Moreover, if the above conceptualization (i.e., Figure 1) is correct, then the vertical flux of water between the DM and the underlying WBZ must be calculated using Darcian flow (Todd, 1980)⁴; no such calculations are presented. From the write up, it appears that the HELP model was used to estimate recharge directly to the WBZ, assuming that the lower portions of the DM is unsaturated; this is inconsistent with the schematic in Figure 1. Either way, consistency in conceptualization and model usage is needed.

Also not documented are the calculations and resulting values for the concentrations of COCs applied to the estimates of recharge obtained from the HELP model. While the report suggests that COC concentrations in recharge water are based on equilibrium partitioning calculations, no such calculations are presented.

Comment 17 – Appendix M, Section II.D: Modeling of Leaching and Groundwater Transport: The application of ground water fate and transport modeling is also poorly documented in Appendix M, prohibiting the ability to confirm calculations. There are also a number of inconsistencies in the application of the model; these include:

³ WHO. (2005). The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds. Retrieved from: http://www.dow.com/facilities/namerica/michigan/dioxin/WHO_TEF_re-evaluation.pdf

⁴ Todd, D.K. (1980). Groundwater Hydrology, 2nd Edition, J. Wiley & Sons, New York, NY.

- The hydraulic conductivity (K) value used in the ground water model was estimated based on the geometric mean value of slug test results from four locations within the WBZ (see Table 5 of Appendix M). However, elsewhere on Table 5, a combination of harmonic means, arithmetic means, and geometric means is used to estimate overall K values, with no rationale outlined other than one reference (Freeze and Cherry, 1979) to the use of harmonic mean for layered soils. This arbitrary use of a range of methods to “average” K values lacks scientific defensibility. To maintain the necessary conservatism inherent to risk assessment efforts, the maximum value of K for each zone should be used. At a minimum, such values should be used in a sensitivity analysis to evaluate their significance on the modeling and risk assessment conclusions; no such uncertainty analysis has been performed. The need for a sensitivity analysis is further emphasized given the significant uncertainty and potential underestimation of K values obtained from slug test results (Butler, McElwee, and Liu (2005)⁵.
- The estimation of attenuation factors along the path of ground water migration from the IRM to the surface water bodies included the effects of adsorption, which is a highly complex, site-specific, and reversible process under actual field conditions (Su and Lu, 2007)⁶. In contrast, the AT123D model used in the analysis represents this process via a simple linear isotherm based in large part on user-defined chemical-specific distribution coefficients (Kd), soil bulk density, and porosity. In turn, the Kd's are in part based on the site-specific fraction of organic carbon in soils. Of particular concern is that none of the key parameters (porosity, bulk density, fraction of organic carbon content) necessary to estimate the retardation factors were based on site-specific measurements.

Recognizing the highly complex and reversible nature of retardation, the absence of key site-specific data, and the inability to generate defensible estimates of retardation factors, the AT123D model should be applied without the use of retardation. At a minimum, such simulations should be incorporated into a sensitivity analysis for the modeling and risk assessment.

- The representation of the COC source term in the ground water model lends itself to a potentially significant concern. The rectangular vertical source term used in AT123D assumes a fully penetrating source term within the WBZ. As such, in estimating the source term concentration, the COC mass estimated to recharge (i.e., presumably estimated as the product of the recharge rate and the pore water concentration at equilibrium with the COC soil concentrations – calculation not shown) was uniformly mixed and diluted within the entire aquifer thickness in the WBZ. In the absence of localized ground water pumpage and density-driven mixing, the actual mixing zone depth of recharge is expected to be measurably less than the entire aquifer thickness, resulting in higher source concentrations within the upper portions of the aquifer. By uniformly mixing this mass within the entire aquifer thickness rather than a fraction of the aquifer

⁵ Butler, J.J., McElwee, C.D., and Liu, W. (2005). Improving the Quality of Parameter Estimates Obtained from Slug Tests, *Ground Water*; 34 (3): 480 – 490.

⁶ Su, F. and Lu, C. (2007). Adsorption kinetics, thermodynamics and desorption of natural dissolved organic matter by multiwalled carbon nanotubes. *J Environ Sci Health A Tox Hazard Subst Environ Eng*; 42 (11): 1543-1552.

thickness (see Equation 3 on Page 12 of Appendix M), the COC concentrations inserted into the ground water model were reduced. As with several other parameters, the value used to represent the mixing zone depth was arbitrarily assigned with no technical justification, resulting in the lowest source term possible in the ground water model; this approach lacks technical defensibility.

Worth noting is that the USEPA has developed technical approaches for estimation of mixing zone depths (e.g., Sharp-Hansen et al., 1990)⁷, which should be used in lieu of arbitrarily assigned depths. In addition, sensitivity analysis of this term should also be performed.

- The effective porosity term in the model is not well supported and appears to be inconsistently selected. On Page 11 of the RI Addendum, the ground water seepage velocity within the WBZ is calculated based on an effective porosity of 0.25 without the benefit of any site-specific measurements and/or references. In the ground water model, the effective porosity for the WBZ was arbitrarily increased to 0.30 (see Table 7 of Appendix M), thereby reducing the ground water velocity by approximately 20 percent. Note also that for the silty sands such as those within the WBZ, effective porosities on the order of 0.15 are not unusual, yielding significantly greater seepage velocities than those estimated in the RI Addendum and by the model. Consistency and defensibility in such key parameters is necessary. As before, a sensitivity analysis on this parameter is also recommended.

Comment 18 – Appendix M, Section II.E: Groundwater Mixing with Surface Water: As with the original risk assessment, there remains a fundamental flaw in the use of attenuation factors beyond the points of ground water discharge to surface water bodies in an effort to dilute the exposure point concentrations (and maximize CSLs) at surface water bodies.

First, the estimation of an attenuation factor (for human receptors) based on the ratio of the ground water flux to the overall surface water flux in the river is not only incorrect, but essentially guarantees the continued pollution of the surface water bodies into the future. It goes without saying that this attenuation factor will be significantly high, given the minute proportion of ground water discharge in comparison to flux in rivers as large as the Delaware River; not surprisingly, Todd (1980) suggests ground water contribution to base flow in rivers constitutes approximately 20 percent of the river's total flow.

The primary problem with this approach is that it suggests that one can discharge as much mass as necessary into a river, as long as that mass is met with sufficient dilution based on the flux ratio between the river and ground water. Functionally, this would allow every polluter along the river to discharge significant mass into the river and simply achieve compliance by performing a flux-only based dilution calculation, which will favor discharging almost any amount of soluble mass into the river. This is in direct conflict with the need to protect the water quality of the rivers at stake.

⁷ Sharp-Hansen, S., Salhotra, A.M., Mineart, P., and Allison, T. (1990). Multimedia Exposure Assessment Model (MULTIMED)-Evaluating the land disposal of wastes-Model Theory. USEPA Office of Research and Development, Environmental Research Laboratory, Athens, GA.

Second, even if dilution within a river is considered a justifiable means to eliminating pollution, the dilution calculation should not be solely based on the ratio of the flux of the two sources of water; rather, it should account for the existing mass of each COC already within the surface water system in order to eliminate the potential for each polluter to indefinitely discharge chemical contamination into the river without any recognition of mass limits. No such accounting was made in the calculations in either risk assessment, despite the known detection of COCs in the river and within fish species tested. Along the lines above, the use of a dilution factor of 10 for the ecological component of this analysis is similarly inappropriate, not to mention entirely arbitrary and without technical basis.

With respect to relying on surface water dilution, it should be noted that many regulatory agencies prohibit the use of such dilution for the reasons stated. In fact, not only do many agencies not allow for surface water dilution in such analyses, they in fact suggest that the AWQC be applied not at the point of ground water discharge to the bay, but at a distance inland corresponding to the inland extent of tidal effects. Tidally influenced ground water, which at the subject site exceeds 200 ft inland from the rivers, is accordingly considered a part of the surface water body given its rapid and daily hydraulic communication with the surface water body. As such, application of the AWQC to an ecological protection zone in land (i.e., distance defined by tidal influence) ensures protection of aquatic organisms and minimizes the potential for continued manifestation of river impacts. This approach, which has been adopted by the California Environmental Agency at the San Francisco International Airport site (California Regional Water Quality Control Board San Francisco Bay Region, 1999)⁸, is a marked difference from what has been proposed at the subject site.

COMMENTS ON DNREC'S 10/10/08 DATA REPORT EVALUATION

Our review of this DNREC evaluation report follows:

Comment 19 – Evaluation Results: In general, we concur with the findings under this header. Regarding Bullet No. 2, it is important to note that DuPont has presented conflicting information regarding the dredged material in their March 2, 2007, comments document and in their recent RI/RA Addendum Report. In particular, no data or understanding of the DM was presented in earlier documents and in the recent RI/RA Addendum Report, a thorough history is presented on how the DM was placed and what the DM contains.

Regarding the solid bullets at the end of this section, we concur with every item.

Comment 20 – DNREC Evaluation of COCs:

Organic Contaminants

Please see comments above regarding organic contaminants.

⁸ California Regional Water Quality Control Board San Francisco Bay Region (1999). Order No. 99-45. Adoption of Revised Site Cleanup Requirements and Rescission of Order Nos. 95-136, 95-018, 94-044, 92-152, and 92-140 for: The City and County of San Francisco, The United States Coast Guard, and San Francisco International Airport Tenants/Operators. Retrieved from: www.waterboards.ca.gov/sanfranciscobay/board_info/orders/99-045.doc

Inorganic Contaminants

Based on our preliminary review of these items and information, we concur with DNREC's review, conclusions, and recommendations.

COMMENTS ON DNREC'S ADDITIONAL COMMENTS ON RI/RA – OCTOBER 2008

Our subconsultant, LRM, reviewed this document and their comments have been included as Attachment 1. The DNREC's document has been included in its entirety and our comments and edits have been shaded gray.

We have endeavored to complete the services identified herein in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. No other representation expressed or implied is included or intended, and no warranty or guarantee is included or intended in this report, or any other instrument of service.

The above information represents our review of the referenced documents. If you have questions concerning this submittal, please contact us at 610-696-6066.

Sincerely,

SCHNABEL ENGINEERING, LLC



Michael S. Roscoe, P.G.
Senior Associate

MSR:MHD;jlm

Attachment:

- (1) DNREC Additional Comments on Remedial Investigation and Risk Assessment Report Addendum – Edited by LRM

ATTACHMENT 1

DNREC Additional Comments on Remedial Investigation and Risk Assessment Report Addendum

**DNREC Additional Comments on 'Remedial Investigation and Risk Assessment
Report Addendum, Hay Road Sludge Drying Site (DE-024) Wilmington, Delaware,
September 2008 Draft', DuPont Corporate Remediation Group**

October 2008

1. **General Impression:** Overall, the report does a good job in compiling the data, information, and analyses available for this site.
2. **Sufficiency of Cap-in-Place Remedy to Protect Human Health:** The report concludes that the "...results of the updated site-specific exposure and risk evaluation demonstrate that the implementation of the cap-in-place remedy is appropriate as it is protective of human health and the environment." The cap-in-place remedy should be sufficient to protect humans from elevated exposure to organic contaminants, in particular PCBs, dioxins and furans, and hexachlorobenzene. This position is based largely on the tendency of these contaminants to strongly adsorb to soil rather than leach into groundwater. So long as wind and water erosion are controlled through use of a permanent cap, release to the surrounding environment should be minimized going forward. The fact that a permanent cap may be sufficient to control organic COCs in the future doesn't mean that these organic COCs were fully controlled in the past; this includes COCs which have already migrated to significant depths within the iron rich material (IRM) and dredge material (DM), and those which have leached to groundwater and are subject to continued discharge to the surface water bodies independent of the effects of a permanent cap. Evidence that they weren't fully controlled will be presented and discussed later in these comments.
3. **Sufficiency of Cap-in-Place Remedy to Protect the Environment:** The cap-in-place remedy by itself seems to be insufficient to fully protect aquatic life in the Shellpot Creek. Specifically, mass balance calculations performed as a part of this review indicate that there is a reasonable potential for soluble iron discharged via groundwater from the first Water Bearing Zone (WBZ) beneath the pile to cause or significantly contribute to exceedances of the applicable numeric water quality criterion for iron in the lower Shellpot Creek during low flow conditions. There is also a reasonable potential for the groundwater discharge of iron (and possibly manganese) to violate the narrative criterion in Delaware's Surface Water Quality Standards that requires waters of the State to be free from wastes that may coat or cover submerged surfaces and create a nuisance condition. Soluble iron and manganese discharged from the groundwater rapidly form solid precipitates under normal pH and oxygen conditions typical of surface waters. These precipitates have been observed along the banks of the Shellpot Creek, although the areal extent is not clear. Additional comments concerning the groundwater discharge of iron from the WBZ to the Shellpot Creek follows.
4. **Section 5.2, Site-Specific Groundwater to Surface Water Evaluation:** This section of the report describes how maximum theoretical screening levels for IRM and IRM pore water/leachate were back-calculated from ambient water quality

criteria. The back-calculation procedure involved the application of 2 'attenuation factors', one to account for dilution in the Shellpot Creek/Delaware River and another to account for fate processes in the groundwater. The back-calculated maximum theoretical concentration in the pile was then compared to measured concentrations in the pile. Several concerns exist with this method, including the fact that this back-calculation procedure ignores the elevated concentrations of soluble iron already in the first WBZ. In essence, the procedure assumes that the only iron of concern is iron in the IRM situated above the WBZ and whether iron leaches from the IRM. Since iron was not detected above 52.2 ug/L in the leaching tests on the IRM, the authors improperly conclude that iron does not leach from the IRM. These results simply mean that iron was not detected above a detection level of 52.2 ug/L, not that iron doesn't leach from the pile. This is likely a situation where detection levels were not sufficiently sensitive to properly characterize the leaching potential of the IRM. Indirect evidence that iron is in fact leaching from the pile (at concentrations less than 52.2 ug/L) is the existence of a strong vertical concentration gradient for chloride in the pile (see section 3.2.3). Chloride is a major constituent of the IRM. It is highly soluble and a vertical gradient suggests dissolution of IRM within the pile. If the assumption is made that IRM is essentially ferric chloride, then 1 mole of iron would be released for every 3 moles of chloride. The higher chloride concentration at depth could also mean that dissolution of the IRM is more likely to occur at the bottom of the pile where redox may be low (separate leaching tests of IRM collected at the bottom of the pile and run in the absence of oxygen might yield higher leachable iron). Further, lower pH at the bottom of the pile at the IRM/DM interface would also favor conversion of solid ferric iron to soluble ferrous iron, providing another possible explanation for the high soluble iron concentrations in the DM and WBZ. The point of all this is that the groundwater modeling performed apparently did not consider some important geochemical processes that are likely to have an effect on this situation. Further, by focusing exclusively on how much iron could leach from the IRM, the authors neglect the high concentrations of soluble iron already in the WBZ that lies within groundwater flow pathway between the IRM and the Shellpot Creek. Although DuPont appears to neglect the soluble iron in the back-calculation exercise, they acknowledge its presence elsewhere in the report (section 3.4.1). They imply that the source of that iron is the dredged material (DM) at the bottom of the pile. Even if all of the soluble iron in the first WBZ did come from the DM, which is doubtful for reasons discussed above, the act of placing nearly 30 feet of IRM on top of the DM likely changed the redox conditions in the DM, facilitating the conversion of insoluble and immobile ferric iron to soluble and mobile ferrous iron. DuPont further fails to recognize that they own not only the IRM in the pile, but also the land under the pile. As such, they are responsible for controlling the release of soluble iron from the first WBZ beneath the pile, regardless of whether the IRM is the source of all, some, or none of the iron the first WBZ. At this point, it is unclear whether a permanent cap will significantly alter groundwater flow and the discharge of soluble iron to the Shellpot Creek. Further analysis of this question is warranted, especially given that the impacts to the surface water

bodies from chemicals already in groundwater are additive to those which are estimated to leach from soils and discharge to surface water in the future.

5. **Ambient Concentrations of Iron near the IRM Staging Area:** Readily available and existing data on iron concentrations in surface water and sediments from the Shellpot Creek and Delaware Estuary were compiled and reviewed to place the IRM Staging Area into broader context. Selected findings from those reviews include the following:
 - a. The concentration of total iron in surface water samples collected from the Shellpot Creek increases significantly in the downstream direction going from Route 13 to Hay Road to the lower tidal reach adjacent to the IRM Staging area. The applicable water quality criterion for iron (1000 ug/L) is seldom exceeded in the upstream samples, while virtually always exceeded at the Hay Road station and the station in the lower tidal reach adjacent to the IRM staging area.
 - b. The concentration of iron in the sediments of the lower Shellpot Creek ties the maximum published concentration of iron in sediments from the entire Delaware Estuary from Trenton to Cape Henlopen to Cape May.
 - c. There is a statistically significant increase in total iron concentrations in the water column of the Delaware Estuary as one travels from Marcus Hook (upstream) to Cherry Island (adjacent to the IRM pile). The water quality criterion at the Marcus Hook station is exceeded in 40% of the samples while the criterion is exceeded in 90% of the samples collected at Cherry Island station. Below the C&D Canal, the concentration of iron in the water column drops off significantly, with only 30% of the samples collected at Liston Point exceeding 1000 ug/L. In terms of time trends, there is some evidence that contemporary (2006-2007) water column iron concentrations in the Delaware Estuary downstream of the IRM pile are much higher than historic levels (1957). This finding is subject to verification, however, since field and laboratory methods associated with the older data may not be comparable to methods used to collect and analyze the more current data.
 - d. The concentration of iron in the sediments of the Delaware Estuary increases as one travels from the PA/DE line (near Marcus Hook) downstream into Zone 5 of the Estuary. Concentrations then drop off dramatically as you move into the Delaware Bay. The median concentration of iron in the sediments from Zone 5 of the Delaware Estuary (3.34%) is higher than the median for hundreds of samples collected in coastal waters collected between Massachusetts and Virginia (2.26%) as a part the EPA's EMAP initiative.
6. **Section 2.4, Surface Water Hydrology and Storm Water Runoff:** This section notes that, "All surface water drainage is controlled by ...perimeter berms. All storm water runoff exits the Sludge Drying Site to the Delaware River at the southeastern corner after passing through several sediment control devices." Although perhaps beyond the immediate scope of Section 2.4, it is unclear whether storm water runoff would continue discharge to the Delaware River through these same sediment control devices based on the final grading and

permanent capping envisioned by DuPont. It is also unclear whether these sediment control devices have been maintained to ensure peak efficiency and whether they will continue to be maintained and monitored should a permanent cap be installed. This section also notes that, "The Sludge Drying Site is surrounded by a berm made of low permeability silts/clays, probably from historical DM or clayey/silt river deposits." Given that the IRM has been allegedly used in other berm and cover installations in the area, the question arises whether IRM was also used in the berms at the Sludge Drying Site. If so, there may be a need to cap the berms as well to prevent the erosion of contaminants of concern into the lower Shellpot Creek and Delaware River. At a minimum, the mass loading and related risks to surface water from such runoff and/or the potential for recharge of runoff water and related impacts to surface water should be quantitatively evaluated in the risk assessment.

Finally, this section indicates that, "Because the Sludge drying Site is located at the confluence of the Shellpot Creek and the Delaware River and below the Shellpot Creek tidal gate structure, a large amount of water exists in Shellpot Creek next to the site relative to the stream flows recorded upstream at the gaging station....A value of 10 cfs is considered representative for a conservative long-term average flow past the Sludge Drying Site." It is true that the lower Shellpot Creek is tidal in the reach adjacent to the Sludge Drying Site. It is not true that increased dilution is available just because the lower Shellpot is tidal. In tidal waters, water moves upstream during flood tide and downstream during ebb tide. The net movement of water in the downstream direction is in fact determined by the nontidal component of the flow through the tidal reach, which is the freshwater flow entering the tidal reach. DuPont understands this concept in the case of the tidal Delaware River in which they present a mean harmonic freshwater flow of 7,402 cfs for the Delaware River in the vicinity of the Sludge Drying Site (although they fail to present a net advective flow under critical low flow conditions). In the case of the Shellpot Creek, the 7Q10 low flow at the Shellpot Creek gage located downstream of North Market Street in Wilmington is 0.22 cfs. That flow translates to a 7Q10 of 0.29 cfs near the mouth of the Shellpot Creek based upon the ratio of drainage areas above the tidal reach in comparison to the gage. The long-term median (50%) flow at the gage is 2.9 cfs, which translates to a long-term median flow of 3.77 cfs at the mouth of the Shellpot. Hence, DuPont's characterization of 10 cfs as being representative for a conservative long-term average flow past the Sludge Drying Site is not accurate. Further, it significantly understates the amount of flow available during critical low flow (e.g., 7Q10) conditions.

7. **Section 3.5.2, Comparison of Organic COCs to Screening Criteria:** This section states that, "Total PCB concentrations [in surface water samples] ranged from 24,700 picograms per liter (pg/L) upstream of the Sludge Drying Site (DNREC location I-495 to Wires) to 11,708 pg/L (SI location SC-2). However, individual PCB congener and dioxin/furan distribution patterns generally differed from the IRM 'fingerprint' as defined in Section 3.2.2." It is true that the PCB and dioxin/furan fingerprints in the surface samples differ from that of pure,

100% IRM. However, the presence and dominance of PCB-209 in water samples collected between the tide gate and mouth of the Shellpot is unmistakable (Greene, 2008e). The PCB fingerprint of the surface water at this location represents a mixture between the PCB fingerprint of the IRM and non-IRM PCB. Furthermore, the concentration of PCB-209 in the water sample collected between the tide gate and mouth by DNREC in the fall of 2007, 757 pg/L, exceeded the human health criterion of 64 pg/L by itself, independent of any other congeners in the sample. The fact that PCBs have been detected in surface water also undermines the water flux-based dilution calculations, which inappropriately assume complete mixing of chemically-impacted groundwater with large volumes of chemical-free surface water.

8. **Section 3.6.2, Comparison of Organic COCs to Screening Criteria:** This section notes that, "...individual PCB congener and dioxin/furan distribution patterns generally differed from the IRM 'fingerprint' as defined in Section 3.2.2. OCDF was detected at lower concentrations than OCDD, and PCB 209 did not dominate the total PCB mass present." Again, although it's true that the PCB fingerprint for sediments collected below the tide gate are not 100% derived from the IRM, it is perfectly clear that IRM has been incorporated into these sediments. As for the surface water sample collected at the same location, the PCB fingerprint for the sediments collected between the tide gate and the mouth represents a mixture between the fingerprint of the IRM and PCBs on non-IRM origin.
9. **Section 3.8, Biota:** The second paragraph in this section needs to be completely rewritten since it is largely inaccurate and incomplete. Here are some facts related to the Shellpot Creek fish tissue sampling conducted by DNREC in the October of 2007:
 - a. These samples were collected in support of several different DNREC programs, including: TMDLs, fish advisories, waste site cleanup, and natural resource damage assessment.
 - b. Fish tissue samples were collected at 6 stations throughout the Shellpot Creek, spanning the entire watershed from its headwaters down to the reach between the tide gate and the mouth. No sample was collected from the Delaware River as a part of that work as indicated in the text of DuPont's report.
 - c. Based on availability, small whole body fish were collected and analyzed from some stations, while separate fillet and remains samples were collected and analyzed from other stations. The stations with separate fillet and remains results were combined based upon their relative masses and concentrations to calculate contaminant concentrations in the whole body of the fish. This allowed for a comparison of contaminant concentration on a whole body basis across the watershed.
 - d. A preliminary assessment of the data indicates that Total PCB in whole body fish ranged from 40.5 ppb ww (Cardiff Park, headwaters) to 2,782 ppb ww (below I-495). Concentrations increase from Lea Blvd to the 'below I-495' station, then decline to the 'tide gate to mouth' station.

- e. The concentration of PCB-209 in the 'tide gate to mouth' fish sample is much higher than in any of the other samples. The PCB fingerprint for this sample reflects the accumulation of PCB-209 in fish associated with the release of the IRM to the lower Shellpot Creek. Again, the PCB fingerprint in the fish at this station is not identical to 100% IRM. Rather, the fingerprint in the fish at this station reflects a mixture between that of the IRM and that of non-IRM PCB.
- f. The concentration of dioxin and furan TEQs in whole body fish increased from 0.29 pg/g ww (Cardiff Park, headwaters) to 4.25 pg/g ww (tide gate to mouth sample). Dioxin (2, 3, 7, 8-TCDD) was detected in all 3 samples downstream of Governor Printz Blvd, but not in the samples upstream of Governor Printz Blvd.
- g. Fingerprinting revealed that OCDD dominated the dioxin and furan mass in all fish samples except the one collected between the tide gate and mouth. This latter sample was composed of a broader mix of dioxins and furans than the other samples. Dioxin and furan TEQs in all of the fish samples were dominated by lower molecular weight dioxins, particularly 1,2,3,7,8-PeCDD. OCDF, which is a dominant congener in IRM, contributed an extremely small percentage (<0.01%) of the dioxin and furan TEQ in all of the fish samples, including the one collected between the tide gate and mouth.

10. Section 5.2, Site-Specific Groundwater to Surface Water Evaluation: In addition to the detailed comments presented on this section in comment 3 above, the following comment is also made. On page 35, the statement is made that "...unlimited COC concentrations could be present in the capped IRM Pile and still not result in an exceedance of risk-based AWQC in Shellpot Creek or the Delaware River." It is strongly advised that this statement be revised or removed because it is presumptuous and not universally true (e.g. if NAPL were present, which it isn't). It is also inappropriate to allow for infinite amounts of various chemicals to be discharged to the river due to the significantly greater volume of river flows compared to the lower groundwater discharge estimates. This approach, if applied consistently along any segment of the river/creek will inherently result in the continued build-up of contamination in the surface water despite dilution calculations which seemingly suggest otherwise. Note also that the dilution calculations performed do not take into account the mass loading to surface water from the subject site and other sources, evidenced by the existing levels of chemicals detected in the river/creek and measured in various fish species.